are compared. As shown in FIG. **57**, in the IE-type trench IGBT device "X", the switching loss is shown as a change of about 30% when the resistivity is changed about 27% (corresponding to variations in the resistivity in the axial direction of the CZ crystal ingot), whereas in the non-IE-type trench IGBT device "Y", the swinging loss becomes a change of about 90% equivalent to three times the above change. Such a range of vibration is generally hard to be allowed as for a product.

[0530] This is because as shown in FIG. **56**, the injection efficiency of the back surface diode must be increased to reduce the on resistance in the non-IE-type trench IGBT device "Y", whereas in the IE-type trench IGBT device "X", the whole hole distribution becomes relatively flat for the hole storage effects on the front side. Increasing the injection efficiency of the back surface diode in this way causes a demerit that the dependence of various characteristics on crystal concentration becomes steep.

[0531] Thus, the IE-type trench gate IGBT according to each embodiment of the present application is generally allowed as a product even depending on the crystals grown by the CZ method, and its device design is enabled. A problem however arises in that when the CZ crystal is annealed in the vicinity of 450° C., a Thermal Donor occurs so that a substantial N-type impurity capability or concentration rises. Thus, in this case, it is preferable to use, even among the CZ crystals, one grown by an MCZ (Magnetic Field Applied CZ) method which is relatively low in oxygen concentration. Even among MCZ crystals, the crystals grown by an HMCZ (Horizontal MCZ) method, a CMCZ (Cusp MCZ) method, etc. in particular are suitable in particular. The oxygen concentrations of these low oxygen MCZ crystals normally range from about $3\times10^{17}/cm^3$ to $7\times10^{17}/cm^3$. On the other hand, the oxygen concentration of an FZ (Floating Zone) crystal is normally $1\times10^{16}/cm^3$ or so. The oxygen concentration of a normal CZ crystal free of the use of a magnetic field is normally $1\times10^{18}/cm^3$ or so.

[0532] Incidentally, assuming that a range from about 600 volts to about 1200 volts in breakdown voltage is taken as the range for resistivity of a high resistance CZ crystal particularly adapted to the IGBT, the resistivity range becomes a range from about 20 Ωcm to about 85 Ωcm.

[0533] Thus, when the CZ crystal is used in the IGBT, the CZ crystal has a merit that it is strong in mechanical strength and resistant to thermal distortion unlike the FZ crystal low in oxygen concentration. The CZ crystal also has a merit that it is relatively easy for a wafer to increase in its diameter as compared with the FZ crystal. The more the increase in its diameter, the more the problem of thermal stress becomes important. Therefore, the usage of the CZ crystal is increasingly advantaged. When wafers each having the same diameter are compared in unit price, the CZ crystal is much cheaper (50% or so of FZ crystal in 8 inches).

[0534] Although not essential, it is advantageous for the IE-type trench IGBT device using the CZ crystal to reduce the injection efficiency of the back surface diode in terms of switching characteristics. It is advantageous to use the back-surface aluminum-based contact structure described in the section **13** (refer to FIG. **49**). That is, even though the concentration of the P+ type collector region **18** (refer to FIG. **49**) is reduced, a satisfactory contact can be ensured by the combination of the aluminum-doped region **30** and the aluminum back-surface metal film **17***a*.

[0535] Incidentally, the CZ crystal described in this section can be applied to all the embodiments described in the present application.

[0536] 19. Supplementary Explanations Related to Cell Area Peripheral Structure (Refer Principally to FIGS. **58** and **59**):

[0537] The description of this section is basically related to supplementary explanations related to the section **14**.

[0538] FIG. **58** is an enlarged top view of the cell area corner cutout region R**4** of FIG. **6** and its periphery, which illustrates a portion (peripheral portion other than the cell area in particular) approximately identical to FIG. **50** in more detail. FIG. **59** is a device sectional view (corresponding nearly to FIG. **52**) corresponding to the section taken along line H-H' of FIG. **50**. The supplementary explanations related to the cell area peripheral structure will be made based on these.

[0539] As shown in FIG. **58**, a single to a few dummy cell areas **34** (linear dummy cell areas) are provided at the end of the cell area **10** in the widthwise direction of each linear unit cell area **40** (refer to FIG. **4**) (in the width direction of each of the linear active cell areas **40***a*, linear inactive cell areas **40***i* and the like). A P+ type body contact region **25***d* is provided in the dummy cell area **34** in a manner similar to the linear active cell area **40***a*.

[0540] On the other hand, an area not formed with an end trench gate electrode **14***p* and an N+ type emitter region **12** and the like relatively narrow in width (width of the same degree as the linear active cell area **40***a*) (no N type hole barrier region **24** is formed either in this example) is provided at the longitudinal end of the linear unit cell area **40** (refer to FIG. **4**) as each end buffer area inclusive of the area in which the previous dummy cell area **34** is provided. A ring-shaped P type cell peripheral junction area **35** (second conductivity type cell peripheral junction area) is provided outside these end buffer areas so as to surround these. A P type cell peripheral region **16***p* (peripheral second conductivity type region) that configures the P type cell peripheral junction area **35** is formed in the same process as the P type floating region **16** simultaneously therewith, for example.

[0541] Each trench gate electrode **14** extends over the P type cell peripheral junction area **35** from the cell area **10** as a gate lead-out portion **14***w*. A number of P+ type body contact regions **25***p* (this portion corresponds even to a peripheral contact portion **41**) each having a structure similar to the cell area **10** are provided within the P type cell peripheral junction area **35**.

[0542] A metal emitter electrode **8** covers up to the peripheral external portion of the cell area **10** and is electrically coupled to the P type cell peripheral region **16***p* at the peripheral contact portion **41**. A metal gate wiring **7** extends to the peripheral portion of the metal emitter electrode **8** and is interconnected with the gate lead-out portion **14***w* at a metal gate wiring-trench gate electrode coupling portion **13**.

[0543] Next, a section taken along H-H' of FIG. **58** is shown in FIG. **59**. As shown in FIG. **59**, a P type body region **15** is provided in the surface **1***a* of the semiconductor substrate **2** in the linear inactive cell area **40***i* and the P type cell peripheral junction area **35** or the like in a manner similar to FIG. **52**. An end trench gate electrode **14***p* is provided in the neighborhood of the boundary between the linear inactive cell area **40***i* and the P type cell peripheral junction area **35** and serves as part of the end buffer area. A P type floating region **16** is provided on the lower side of the P type body region **15** lying below the